# Space Weather Technical Forecast

Issued on Saturday, 17 December 2022 at 01:09 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Further M-class flares (R1-R2 Blackouts) likely from AR3165.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Two Coronal Mass Ejections may give slight glancing impacts during 18th or 19th. Solar Activity has been Moderate with occasional M-class flares observed during the past 24 hours, mostly from AR3165 (Ekc/Beta-Gamma-Delta), the largest region, which gave a peak flare of M4 observed at 16/1020 UTC. There are six other sunspot regions on the visible disc. Of these AR3163 Eki/Beta Gamma is the second largest region, a moderately sized spot in the southeast. AR3166 is the third largest with a continued slight growth trend observed. The NEW region currently on the NE limb is noteworthy due to it's probable hidden size and complexity, this spot group has been responsible for several CME's in recent days and is likely just the leader of a larger, more complex active region. The remaining regions on the disc are relatively small, weak and magnetically simple.

**Solar Wind / Geomagnetic Activity:** Solar winds, as observed at L1 by DSCOVR and ACE have been at slow-ambient levels, around 320-340 km/s. Density was below average. The total IMF, Bt, was weak, below 6nT. The north-south component of the IMF, Bz, was weak varying between +5/-5nT. The phi angle was predominantly negative (towards the Sun) throughout. Geomagnetic activity was Quiet (Kp 0-2).

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2 MeV), as observed by GOES16, was at Background to Moderate levels, with peak 190 pfu at 16/2215 UTC. The associated 24-hour fluence decreased through the day, and remained well below Active (1e8 integrated pfu). Observed fluence at 17/0000 UTC was 1.93e6 integrated pfu.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity is likely to be Moderate, especially for days 1 and 2 (16th and 17th) before AR3165 rotates off the visible disc, with further M-flares. There is a slight chance of reaching High levels, with the maximum peak flare potentially reaching X-class.

**Solar Wind / Geomagnetic Activity:** Two CME's may give slight glancing impacts between 18th and 19th. Solar winds are expected to be at slow-ambient levels initially, perhaps becoming slightly elevated day 2 (18th) from the HSS from CH54/-. The aforementioned CME's may also combine with the coronal hole high speed stream arrivals, or give separate glancing impacts spread between days 2 and 3 18th and 19th. The HSS from CH55/+ may then arrive from late day 4 (20th) or perhaps more likely after, likely bringing enhanced solar wind speeds toward the end of the period or beyond.

Quiet geomagnetic activity (Kp 0-2) is expected, with a chance of becoming Unsettled to Active (Kp 3-4), with a very slight chance of G1/Minor Storms (Kp 5) days 2-4 (18th-20th) due to a combination of high speed streams and glancing CME's.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is expected to remain at background levels throughout, although there is slight chance of S1 level

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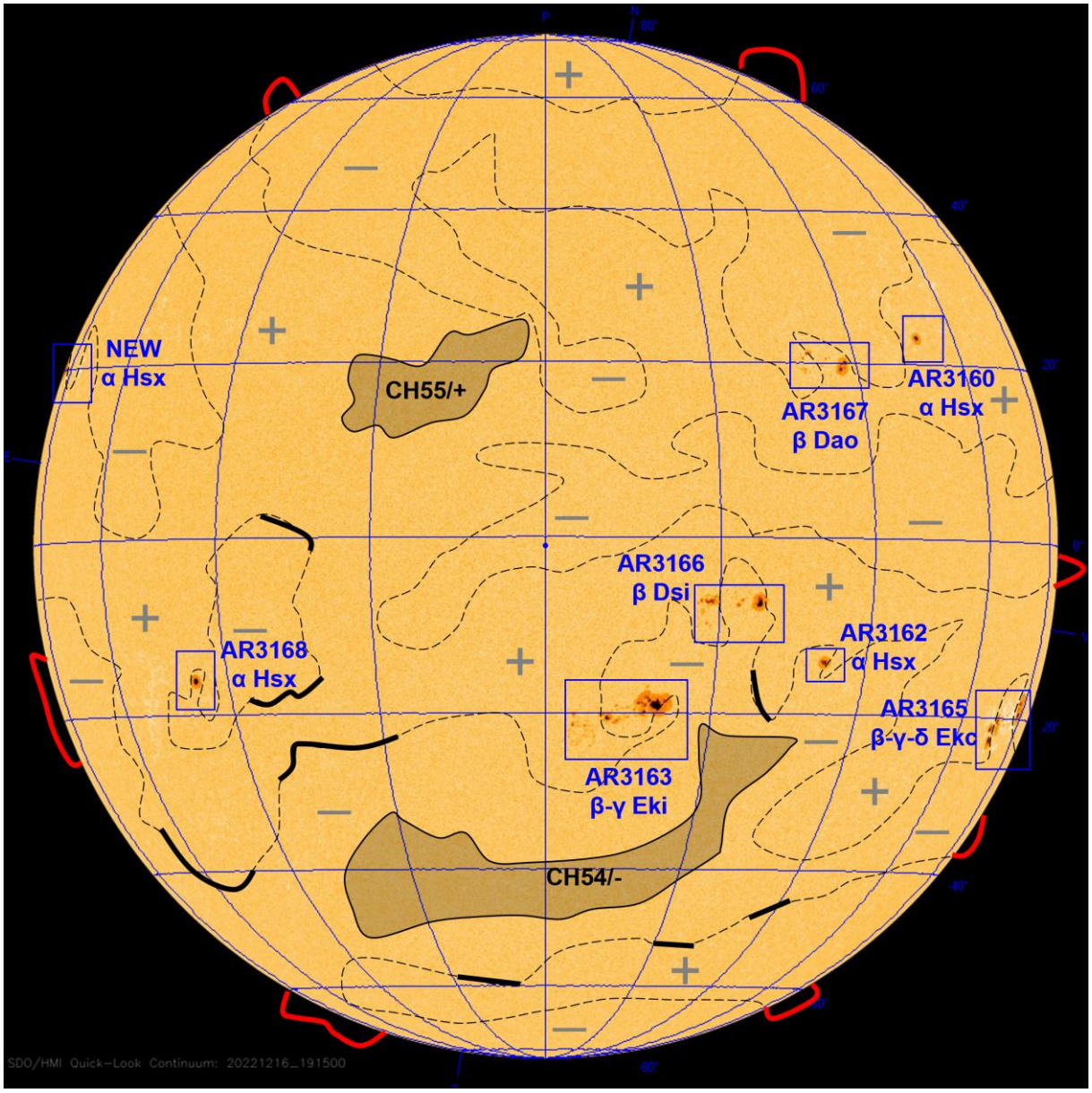
storms with the occurrence of any notable flares. High energy (greater than 2 MeV) electron flux is currently at background to moderate flux levels and expected to persist at these levels. The associated 24 hour fluence is expected to continue well below the Active (1e8 integrated pfu) threshold with a mostly flat trend anticipated.

**Figure 1. Solar Analysis Valid 16/2000 UTC**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

There are currently no Earth-directed CMEs. The filament lift off from the southwest around 14/0300 UTC has been assessed as missing Earth, but brings a slight chance of glancing impacts during day 3 (18th). Similarly a CME which left the Sun on 15th is also assessed as missing Earth, though it may have minor glancing impacts later on 18th or on 19th.

Solar winds are expected to be at slow-ambient levels initially, with the next enhancement arriving around day 2 (18th) from CH54/- currently moving westwards across the southeast disc quadrant. This is a persistent feature, but reduced in size and northward extent compared to the previous rotation. However, its leading (western) edge is in a similar location, suggesting the timing of any enhancement that occurs is likely to follow the 27-day persistence, with solar wind speeds probably reaching slightly elevated around day 2 (18th), reaching up to 450 km/s. This arrival is not obvious in current MOSWOC ENLIL, therefore producing low confidence for a significant enhancement or any subsequent geomagnetic activity. The aforementioned CME's may also combine with the coronal hole high speed stream arrivals, or give separate glancing impacts spread between days 2 and 3 18th and 19th. The high speed stream from coronal hole 55 may then arrive from late day 4 (20th) or perhaps more likely after, likely bringing Enhanced wind speeds for a time. Quiet geomagnetic activity is expected, with a chance of becoming Unsettled to Active, with a very slight chance of G1 Minor Storms days 2-4 (18th-20th).

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 1 | 20 | 20 | 20 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 14/1530 | Partial | Filament | SW | 400 | Early 18th | Low confidence. |
| 15/1743 | Partiall | Unknown | NE | 790 | Poss late 18th | Very low confidence. |

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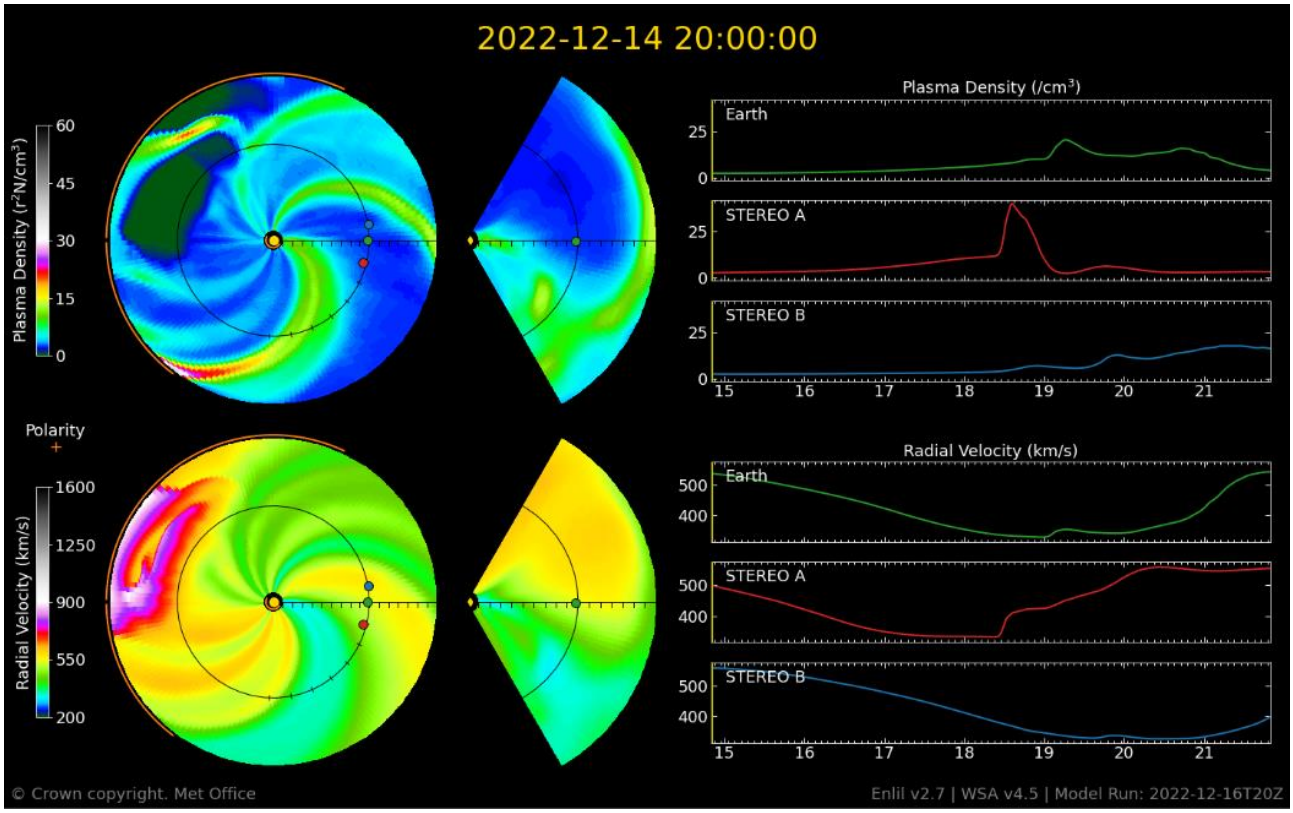
**Figure 2: MOSWOC ENLIL**

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## Radio Blackouts - X-Ray Flares:

There are seven numbered and one new sunspot regions on the visible disk. The most active, and largest numbered region is AR3165, this classified as Ekc/beta-gamma-delta with an asymmetric large leader spot, and has a very complex magnetic field. AR3163 is similarly large with a classification Eki/beta-gamma, having recently lost its delta configuration in it's intermediate region. AR3166 is the third largest and continues on a growing trend. The NEW region currently on the NE limb is noteworthy due to it's probable hidden size and complexity, this spot group has been responsible for several CME's in recent days and is likely just the leader of a larger, more complex active region. The remaining regions on the disc are relatively small, weak and magnetically simple, showing little or no development. There is a slight chance of activity increasing to High with an isolated X-flare, especially in the first two days of the forecast period. This has a reducing trend through the period as the most active sunspot, AR3165, rotates beyond an effective longitude beyond the western limb.

| X Ray Flares<br>Probability | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| Active | R1-R2 M Class | Yes | 80 | 80 | 60 | 40 |
| Very Active | R3 to R5 X Class | No | 15 | 15 | 5 | 5 |

**Figure 3: X-Ray trace past 24 hours**

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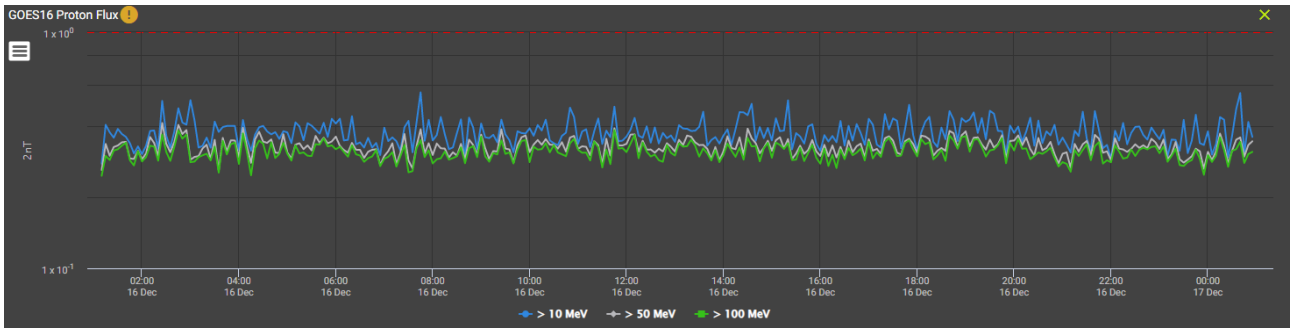
## Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as measured by GOES-16 is expected to remain at background levels throughout. However the frequent M-flaring of AR3165 in the southwest, along with the number of other sunspots on the disc, brings a slight chance of flux levels rising, and potentially exceeding the S1 Minor Radiation Storm threshold. This has a reducing trend through the period as the most active sunspot, AR3165, rotates beyond an effective longitude beyond the western limb.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Active | ≥ S1 | No | 15 | 15 | 5 | 5 |
| Very Active | ≥ S3 * | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

**Figure 4: Proton trace past 24 hours**

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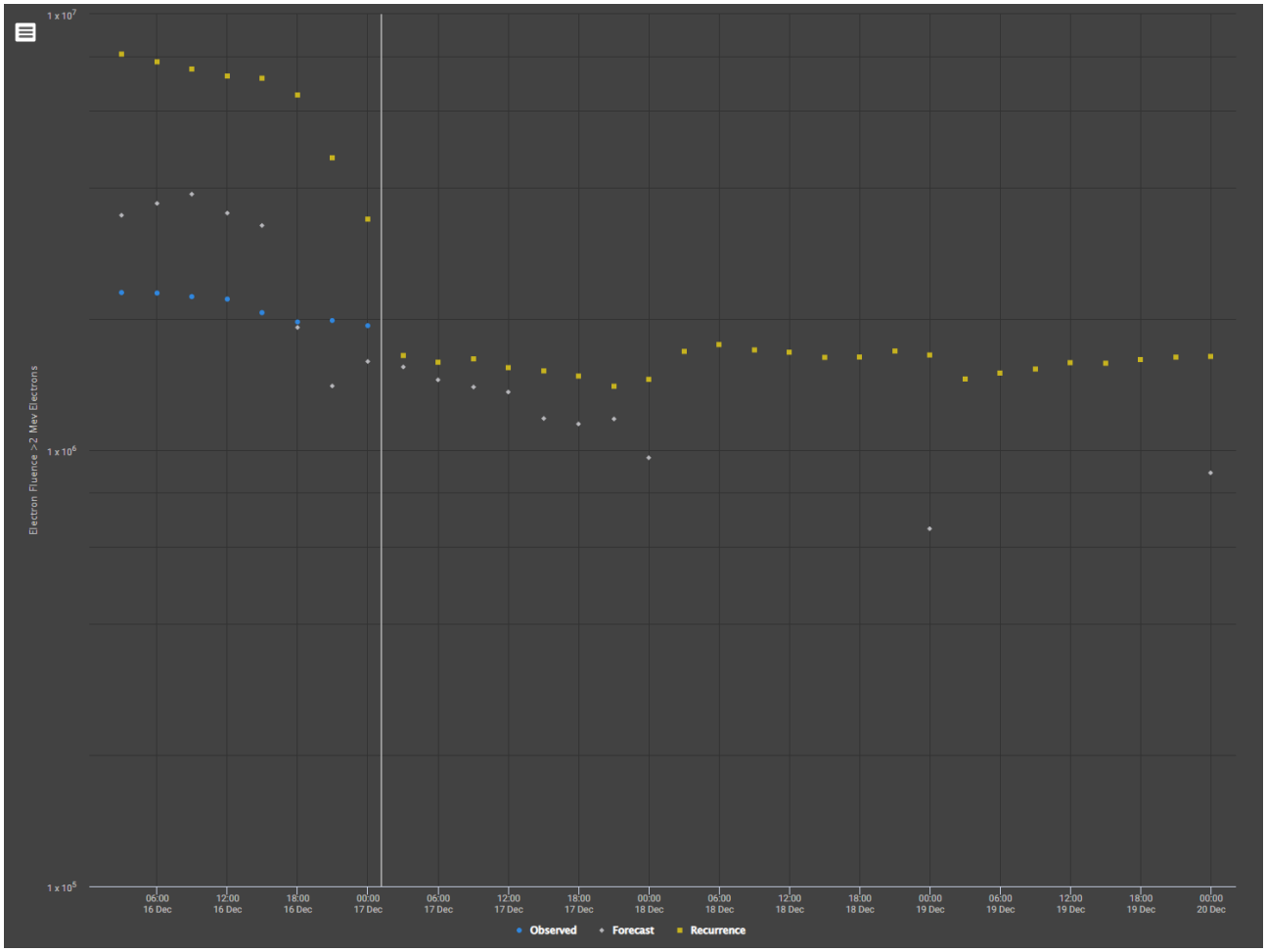
## High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux, as observed by GOES-16, is currently varying between Background and Moderate levels. With no significant solar wind enhancements expected, these electron flux levels are expected to persist through the period. The associated 24 hour fluence is forecast to persist below the active threshold (1e8 integrated pfu). This is supported by REFM output which is currently giving realistic guidance.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 1 | 1 | 1 | 1 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

**Figure 5: MOSWOC REFM integrated flux/fluence observations, foprecats model and persistence.**

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